

SUBSTITUTE SPECIFICATION

TITLE: INFRABASS

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INFRABASS

BACKGROUND OF THE INVENTION

Field Of The Invention

[0001] The invention relates to a bandwidth extension device.

[0002] The invention further relates to an audio reproduction

5 system comprising such a bandwidth extension device.

Description Of The Related Art

[0003] Such a device is known from European Patent Application No. EP-A-0 240 286, corresponding to U.S. Patent 4,790,014.

10 [0004] To improve the aural sensation in low-pitched (this is, signals in the very low frequency band) sound reproduction by an audio reproduction system or the like, a sub-harmonics generator is used to create this low-pitched signal. In this way, a lower pitch signal is created than is present in the incoming signal.

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SUMMARY OF THE INVENTION

[0005] It is an object of the invention to further improve such a bandwidth extension device.

[0006] To this end, a first aspect of the invention provide a
20 bandwidth extension device comprising an input for receiving an input signal, a first signal path and a second signal path whereby the first signal path comprises a filter means for filtering the input signal, creating means for creating an adapted signal with a

lower frequency part than the input signal, combining means for combining the adapted signal of the first signal path with the input signal of the second signal path whereby the second signal path comprises between the input and the combining means delay means. A second aspect of the invention is to provide an audio reproduction system.

[0007] The invention is based on the fact that during the creation of the sub-harmonics, that part of the signal is delayed longer than the non-processed part of the signal. By combining these two signal parts in the combining means, prior art devices generate output signals which consequently have artifacts.

[0008] By delaying the non-processed signal part, it is possible to compensate for the delay in the processed signal part so as to overcome the artifacts generated in the output signals of the prior art devices.

BRIEF DESCRIPTION OF THE DRAWING

[0009] The invention and additional features, which may optimally be used to implement the invention to advantage, will be apparent from and elucidated with a reference to the examples described below and hereinafter and shown in the accompanying drawing, in which:

[0010] Fig. 1 shows a block diagram of a bandwidth extension device according to the invention; and

[0011] Fig. 2 shows a block diagram of an audio reproduction system according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

- 5 [0012] Fig. 1 shows a block diagram of a bandwidth extension device BD according to the invention. A bandwidth extension device can be used in an audio reproduction system to improve the aural sensation of the low-pitched signal-part.
- 10 [0013] At a first input IL, the device receives a left input signal, and at a second input IR, the bandwidth extension device receives a right input signal. Both inputs are coupled to a summing device SUM for summing the both input signals. The output of the summing device SUM is coupled to a band-pass filter BPF1 for filtering the summed input signal to a certain predetermined low
- 15 frequency part. The output of the band-pass filter BPF1 is coupled to a non-linear device NLD for creating an adapted signal with a low frequency part. Sub-harmonics of the lowest part of the input signal are created by the non-linear device NLD resulting in a lower pitch signal than is present in the incoming signal.
- 20 [0014] Reference is made to non-prepublished European Application No. EP 00201509.7, corresponding to U.S. Patent Application Serial No. 09/841,958, filed April 25, 2001 (applicants ref. PHNL000249) owned by the Assignee of the subject application wherein the use of sub-harmonics generators is described in detail.

[0015] The output of the non-linear NLD is coupled to a second band-pass filter BPF2 for filtering out the non-required frequency part.

The output of the band-pass filter BPF2 is coupled to a first
5 combining device COM1 and to a second combining device COM2.

[0016] The first combining device COM1 receives, at a second input, a signal from an all-pass filter APF1 having an input coupled to the first input IL of the bandwidth extension device. The second combining device COM2 receives, at the other input, a
10 signal from a second all-pass filter APF2 having an input coupled to the second input IR of the bandwidth extension device. The outputs of the first and second combining devices COM1 and COM2 are coupled, respectively, to the first and second outputs OL and OR, respectively, of the bandwidth extension device.

15 [0017] By adding the all-pass filter APF1 and the all-pass filter APF2, which have a certain delay, it is now possible to combine, in the combining devices, two signal parts with the same delay. This results in an improved output signal in comparison with prior art devices.

20 [0018] Instead of the all-pass filters, it is also possible to use a delay element.

Further, it is possible to use a controllable delay element which makes it possible to amend the delay in dependence on the delay of the signal path through the band-pass filter BPF1, the non-linear
25 device NLD and the band-pass filter BPF2.

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[0019] Fig. 2 shows a block diagram of an audio reproducing system AS. The audio reproducing system AS includes an input I2 for receiving audio signals. A signal processing device SPD2 processes the audio signals in accordance with the desires of a user of the audio reproducing system AS. An output of the signal processing device SPD2 carrying the processed audio signals is applied to a bandwidth extension device BD2 as described above with reference to Fig. 1. Output signals from the bandwidth extension device BD2 are applied to output O2.

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